P2PEACE: a P2P-based simulation Environment for Autonomic Content Exchange Networks

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Abstract

This paper presents a study on a global replication architecture intended to autonomic content exchange between communities of active nodes. The main objective is to exploit and reuse the synergy of groups to optimize data access in a distributed system. A self management based on thematic similarity between nodes is an efficient manner of optimizing data access (availability and selectivity). The evaluation and the test of such architecture before its large deployment are, however, extremely important. Therefore, a simulation tool called P2PEACE is developed. It is designed primarily to visualize interactions between the network nodes and provide some related statistics to measure the exchange performance. In fact, the existing simulation environments offer good tools of testing the performance of an isolated node (e.g. web cache) or algorithms used for cooperation between groups. However, these approaches do not give a clear vision of the content mobility between the system nodes. In this paper, a method to analyze collective nodes as a global system and understand how contents move around them is, therefore, proposed. Results showed that a semantic organization can greatly optimize the exchanges in such a situation.

1. Introduction

Nowadays, Internet interactions have become extremely popular and by the way have affected the web performance, especially the speed with which content is served to users. In order to overcome this problem, frequently used data could be stored at some locations close to users. In fact, this strategy as, for example, used in proxy-cache will permit to reduce latency (users' waiting time), servers' loads, and bandwidth consumption.

This last technique (isolated proxy cache) is very useful because it can serve content rapidly to a community of users even if the network path is congested. However, the cooperation between groups of proxy caches is generally more efficient especially in the case of great numbers of users. It means that if the primary cache misses, the object in the other cooperating caches can be received instead of requesting it directly from the original server. Different studies to improve this cooperation were found in the literature (see section 5 for more details).

It should be noted that none of these techniques takes into account the influence of the human aspect as this factor largely influences interactions within the network [1]. For example, access to a document can be quicker in a P2P network but can overload servers in Client/Server systems. This rapidity can be explained by the document popularity (i.e. human factor) [2]. We believe that taking into account this factor can improve the efficiency of these systems especially in terms of data access and retrieval.

This paper presents a P2P-based autonomic content exchange system composed of a set of cooperative active nodes. The main idea is that each node connects a group of users having the same interests (a new user can choose a node from a set of thematic nodes and at this step the latter can check for unauthorized access (self-protecting)). Then, a node can link to another one according to its thematic proximity. So the two nodes can exchange a set of documents and in consequences, their users can find a lot of files closer to their center of interest and have rapid access to them. In order to evaluate the performance of this system a simulation environment is developed. However, this tool is more general and it can be used to visualize interaction in several other systems such as cooperative proxy caches systems and self organization in Peer-to-Peer networks.

The rest of the paper is organized as follows: In the next section, the global architecture of the proposed autonomic system is presented. Section 3, gives the design of P2PEACE simulation tool and its implementation. Some of the important results (focusing on content mobility) are discussed in Section 4. The background together with related works is then given. Finally, a discussion of future work is presented.

2. Global Architecture and Autonomic Content Exchange

In this section we describe the architecture of our autonomic exchange system. As we said in the introduction, it is based on an hybrid P2P model combining a peer-to-peer cooperation approach between operators' domains and a hierarchical approach in an operator's domain. Figure 1 gives an overview of the global architecture.

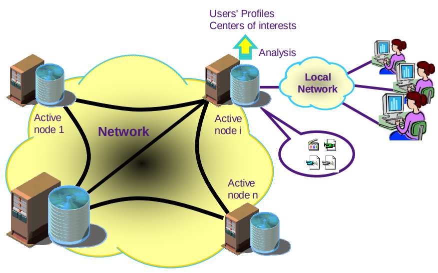

Figure 1. Overview of the autonomic content exchange system

2.1. Global Autonomic Content Exchange Architecture

Most previous studies on cooperative proxy caches (see section 5) focused on serving missed requests. This work, however, looks into the cooperation and exchange of documents and its effect on data access and selectivity. Thus, a P2P-based autonomic network which is composed of a set of autonomic active nodes is proposed. One of the advantages is that contents are available even if users are disconnected from the network or even if a failure occurs in one (or more) node(s) due to the self-healing process based on the replication mode and the cooperation process. This reduces the time needed to scan all nodes as well as the traffic.

2.1.1. Overview of the global self-management architecture.

The global autonomic content exchange architecture is supported by global autonomic management P2P architecture. Similar to the platform PARIS (Platform for the autonomic Administration of netwoRks and the Integration of multimedia Services), see details in [03, 14], the proposed global P2P self-management architecture is composed of three levels:

- The top level (level 1) is dedicated to SLS (Service Level Specification), administrative information, knowledge and contract. It shows for example the management resources use, like the services and nodes profiles.
- The medium level (level 2) represents the autonomic management level which gathers all of the necessary resources for autonomic management services.
- The bottom level (level 3) is not autonomic; it is composed of non autonomic resources and services. It represents physical resources such as switches and routers, as well as logical services such as file servers, web servers and web services.

To deliver an integrated service to customers, the different interconnected service providers have to cooperate through their management domains. The proposed QoS (Quality of Service) criteria are mainly availability, survivability and data access.

2.2. Profiles and Distances

From a certain point of view, the profile gives a reduced image which characterizes its owner (node, user …). It is known that a profile cannot be universal and there are different kinds of profiles. In our case it is a set of weighted "clean" key-words extracted from documents and URLs. Generally, an isolated profile is not very important; however its importance emerges when it is used to compare several nodes. The process of comparison is based on distances which allow the evaluation of proximity between two or several nodes. These techniques are inspired by those used to treat documents like in search engines (Google, Yahoo …). There are a lot of methods of similarity measurement [1] where the well known are matching, Euclidian distance, cosine distance and Dice coefficient or Jacquart coefficient. In this work the use of matching method has been chosen for its simplicity and efficiency [4]. Thus, for two profiles, the proximity will be the percentage of common objects. But in order to take into account what each word represents, its weight is used. In the next formula x and y represent a characteristic vector (for example the frequency of words' occurrence). So nodes with close profiles will be "neighbors". X and Y are neighbors if the proximity between their profiles is smaller than a certain threshold (this procedure can be applied to the nodes or defined locally).

$$d_E(\vec{x},\vec{y}) = \| \vec{x} - \vec{y} \|$$

2.3. Process of negotiation between users and the system and inside the system

The process of SLA (content availability, content accessibility, etc.) negotiation between users and the system is dynamic. It is inspired by PANSEs (Peer Autonomic and Negotiating SErvers) negotiating protocol in [3].

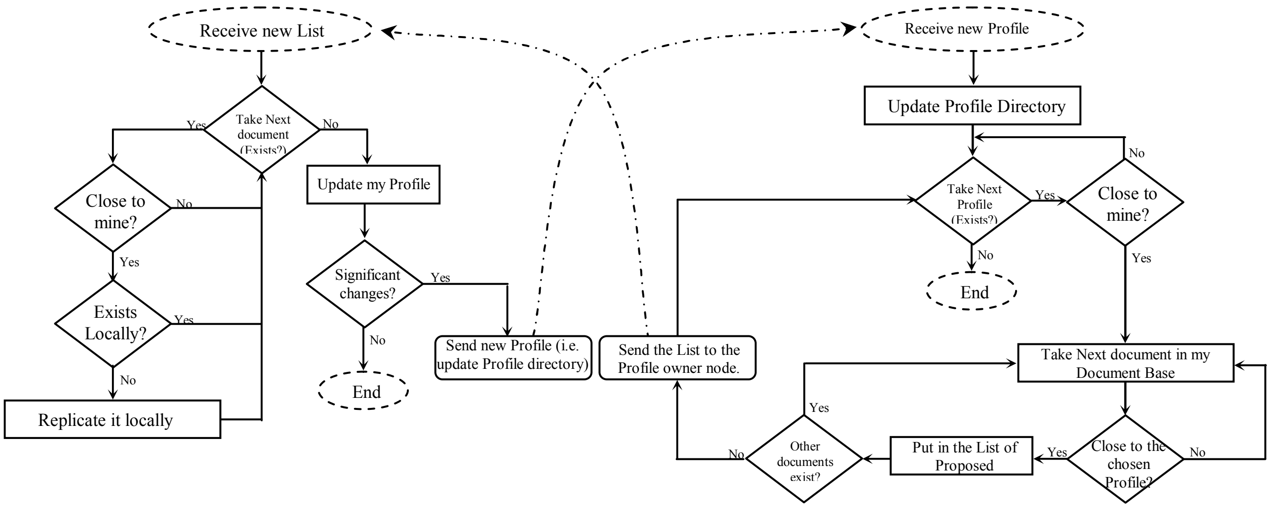

Figure 2.a. Exchanging profiles

Figure 2.b. Exchanging lists of closer documents

Figure 2. Autonomic Exchange Process.

The content mobility among the nodes of the system is guaranteed by each node which makes the system autonomic. First, in self-configuring and self-provisioning modes, nodes exchange information about their content (each node sends its profile to all nodes) using XML standard format. Next, the process of exchange is optimized automatically by selecting a subset of nodes which have a close profile as explained earlier in Section I). In other word, the current node offers and downloads content from these selected nodes. Two possible methods are proposed: in the first one, a node asks others for content close to its profile so they push the file to the seeker. In the second one (used in our case), each node maps objects to profiles by seeing which object is close to which profile and proposes an XML file (contains all close files represented by their profiles and hash code like md5). Finally, a node selects the file to download (following its local policy) as shown in figure 2.

3. P2PEACE Simulation Tool

This section gives some details about the developed tool. It presents the methodology used collecting traces and its main modules and components.

3.1. Simulation Scenario

This paragraph gives a summary of the simulation scenario. It should be reminded that the main aim is to visualize content placement and mobility around nodes.

The first step consists of choosing the simulation context by selecting the number of servers included and the quantity of content constructed following a specific model (power law model, random model…etc.). Then, the profile size is chosen (i.e. the n words the most emerged), the threshold used to calculate documents and profile distance and the one for node proximity. Next, the simulation and visualization of the dynamic graphs which reflect the interactions is launched.

Finally, a set trace files representing the different interactions (sent/received objects, time and amount of exchanges objects …), are produced. At any time, the simulation process can stopped and the generated statistics and traces are analyzed.

3.2. Overview of P2PEACE Architecture

An appropriate simulation written in Java language is conducted. This simulation was designed to evaluate the efficiency of cooperation in an autonomic content exchange system composed of Active nodes. Each node is assumed to exchange content related to its profile with the others. Figure 3 gives an overview of P2PEACE architecture. In this experiment, each node maintains a set of multimedia documents represented by their profile represented by an XML file including its hash code. The main features of this tool are discussed below. It contains four main modules:

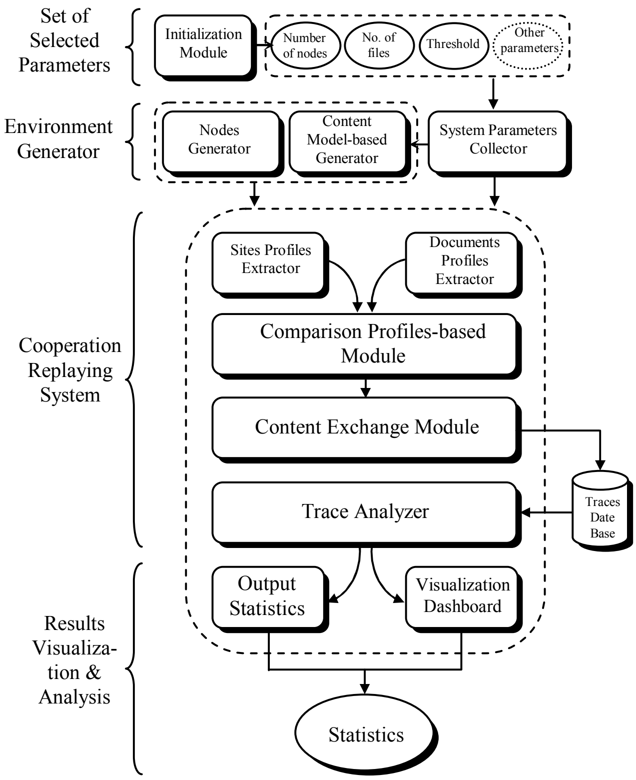

Figure 3. P2PEACE General Architecture.

- Initialization module: this part of the program specifies simulation settings and context by choosing the number of nodes implied in the simulation, the amount of documents per node, the profile size etc. All these parameters have default values which can be changed in every test.
- Environment generator: this second module deals with servers and content generation. For each server is associated certain folders and related information that will be used to store the generated documents, own profile, and other information needed in cooperation such as the profile directory and generated document profiles.
- Cooperation module: this is the most important module of the simulation system. It gathers three important functionalities; the first functionality consists of documents and nodes extracting profiles as explained in 2, the second up to date distributed profiles directory and compares the generated profiles with the servers profiles to decide which documents can be sent to which server, and the last functionality ensures the exchanges by providing an XML document which contains candidate files.
- Trace management module: This module is used to store traces in order to analyze cooperation results. It manages the SQL data base accompanied by generated trace files. This is important especially for the process of comparison.
- Visualization module: It visualizes the interactions between servers in a dynamic way so it facilitates results analysis and interpretation. It is accompanied by some important graphs and statistics about exchanges such as quantity of exchanges, number of replicated objects and the average of interaction every iteration.

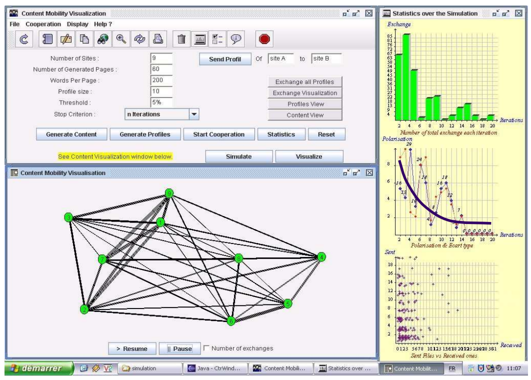

Figure 4. P2PEACE Dashboard.

3.3. Content Exchange Process

The main objective of exchanging documents is that users can find large-object closer to their theme of interest. Let's take for example, universities networks, newer students can find related documents already downloaded by their other or precedent colleagues and other cooperative universities. In this case, a node for each subject or specialty can deployed. So each node in the system analyzes its content and calculates its own profile which is based on document consulted. Such a profile represents the synthesis of the users' centers of interest (which can evolve). Next, nodes publish their profiles in a common distributed directory using XML standard format and based on a specific ontology. This directory is regularly up to date once nodes profiles change. This can be done after a period of time or when the new profile passed a threshold compared to the published one.

Once a node receives an updated directory, it selects a set of semantic closed nodes. This step is introduced to optimize selectivity and consequently reduces traffic on the network (a node does not communicate with all nodes but just with a subset of them). After that each node automatically consults the profiles directory and searches the list of objects closer to each profile. Next, it sends the list to the corresponding node. The receiver decides to accept or not the objects according (self-organization) to its own management policy (file already exist, disc space or the file does not represent a priority...).

4. System Evaluation

The analysis performed in this study focuses on the levels of interactions between nodes and on content mobility. From a macroscopic view, we noticed that exchanges are higher in the starting of the simulation and decrease very rapidly regardless of the quantity of documents.

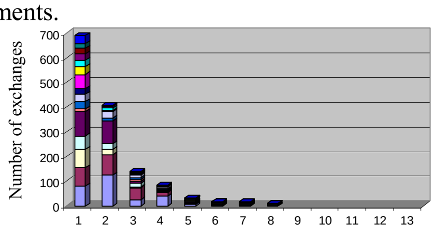

Figure 5. Amount of documents exchanged over the time.

On the other hand, the quantity of exchanges depends on each node and it changes during the next iterations (i.e. Some nodes retrieve more files than others maybe they have a profile close to several nodes). Other results concern the stability of such a distributed system. From Figure 6, It can be noticed that after a certain number of iterations (exchanges between nodes) there is no (or rare) exchange. This convergence confirms that the exchange protocol is consistent and allows stabilizing nodes interactions. This is important in order to limit the overload of network traffic which is a necessary condition for the scalability of such systems.

It is also observed that the number of received (accepted files) is smaller than the number of sent ones (2 files accepted for 5 sent). The refused files mean that the node already has this file or its profile has been changed where other node proposed according to the old one.

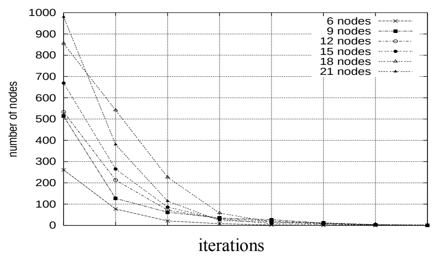

Figure 6. Nodes number influence on the system stability.

The Figures 7 depict the threshold used to compare profiles. As far as its influence on the system stability is concerned, it can be noticed that the improvement of this parameter improves the number of exchanges and prolongs the period of instability.

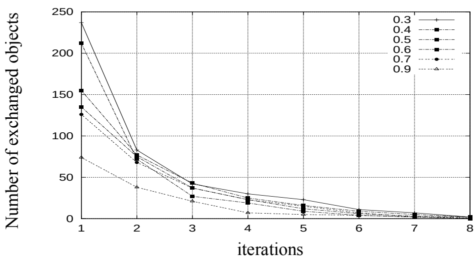

Figure 7. Threshold influence on the system stability.

However, each node in the system can hold several users. It should be noted that these exchanges are lower than users' exchanges. These indicate that autonomous exchanges can help to optimize interactions within the network and facilitate data access and retrieval.

5. Comparison of some related works

To facilitate replication systems design and evaluating their performance, several simulation environments were developed [5, 6, 7, 8, 9, 10, 11]. Each one of these tools deals with a specific angle of this problem. They can be generally classified into two main categories: simulation tools based on artificial traces and those based on real-world traces. In the followings a brief description of these studies is given.

In the first category, we find *WPB* (Wisconsin Proxy Benchmark) [13] and S-Client [6]. These environments use synthetic workloads models to test the performance of proxy caching systems. They are similar to the proposed tool but they are intended to evaluate an isolated proxy server and don't deal with cooperation which is the case with P2PEACE. From another hand, Duska and al. [5] build a trace-driven proxy cache simulator, called *SPA*. This tool allows understanding of Web client access characteristics but it does not give an evaluation of cooperative nodes. The same thing can be said about *Proxycizer* [7] and *WebMonitor* [8]. The first one is a purely trace-driven tool developed to evaluate the performance of proxy cache under various stress conditions. Whereas the second one is used for evaluating and understanding of server behavior. Simulation tools closer to the one proposed here are presented in [10, 11]. In the first work, the author developed a simulation environment which used real traces in order to reproduce interactions between proxies in specific architecture. His aim was to evaluate the performance in terms of latency and economized bandwidth. However, in [11] the authors proposed a tool (*Saperlipopette*) for evaluating the performance of distributed Web cache configurations. The difference with P2PEACE is that the latter focus on the exchanges between nodes and helps to understand content mobility by using generated traces based on several models which are not the case in the previous ones.

6. Conclusion and future work

The proposed P2P-based content exchange architecture offers several advantages over traditional architectures by creating a flexible, reliable and survivable environment. The unification of the traditional roles of manager and element allows functions to be distributed in different elements supporting autonomic behavior. In order to evaluate this approach, a simulation environment called P2PEACE has been developed. This tool gives an insight into the content mobility within such autonomic system. But it can be used in several other contexts as well, such as the cooperation in a P2P network. In this case the nodes of the system can be replaced by the final users.

The results showed that a semantic association of nodes can significantly optimize the exchanges. It is because each node cooperates just with closer ones and not all. However, the use of profiles can be optimized and a study of object exploitation by users still important despite that P2PEACE shows that the system becomes stable after a certain period. Future work deals with such a system in the case of user mobility (in mobile networks). An implementation of the proposed autonomic system is envisaged to study more characteristic on a real context of usage.

7. References

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